Proposal for an Acoustic Classification Scheme for Housing

Rasmussen, Birgit; Gerretsen, Eddy

Published in:
COST Action TU0901 – Building acoustics throughout Europe. Volume 1: Towards a common framework in building acoustics throughout Europe

Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

cost
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

COST Action
TU0901

Building acoustics throughout Europe

Volume 1: Towards a common framework in building acoustics throughout Europe

5

Proposal for an Acoustic Classification Scheme for Housing

Authors:
Birgit Rasmussen[1]
Eddy Gerretsen[2]

[1] SBi, Danish Building Research Institute, Aalborg University (AAU-CPH), Copenhagen, Denmark. e-mail: bir@sbi.aau.dk

[2] Level Acoustics BV, Eindhoven, The Netherlands. e-mail: eddy.gerretsen@planet.nl

CHAPTER 5 Proposal for an Acoustic Classification Scheme for Housing

5.1. Introduction

Classification schemes specify different quality levels of the acoustic performance for airborne and impact sound insulation, protection against outdoor sound and sound due to service equipment. Based on the lessons learned from existing classification schemes and from regulatory requirements in Europe, a balanced European scheme has been proposed, using the acoustic descriptors recommended by TU0901 (see Chapter 3 about descriptors). A review of existing classification schemes is shown in Chapter 2, and summary information is presented in 5.2 as a background for the considerations in 5.3 about development of the TU0901 proposal. The complete TU0901 proposal is presented in 5.4.

5.2. Existing acoustic classification schemes for housing

Table 2.8, gives an overview of the existing classification schemes in Europe. Only schemes with a minimum of three levels are included, thus excluding regulatory documents indicating only a main level and an enhanced level. Details on descriptors used in existing schemes can be found in references in Chapters 2 and 5.4.11, and some indications are found in Chapter 2, mainly in Figures 2.7 and 2.8.

For decisions on future class criteria compared to existing schemes, a comparison between the schemes must be based on translation of the applied descriptors into common, proposed descriptors. For regulatory requirements, this is already partly done in Figures 2.2 and 2.3 with limit values converted to common descriptors for comparability - down to 100 Hz only as currently applied in most countries. The issue is further elaborated in [9] using the descriptors proposed in Chapter 3. The results are used to get an indication of the steps between classes and the total range of existing class criteria. An illustration of this is given in Figure 5.1 for airborne and impact sound.

The results in Figure 5.1 can be compared with the Figures 2.7 and 2.8 in which the class criteria are shown without translation, thus illustrating the present chaotic situation. The figures also show that the regulatory

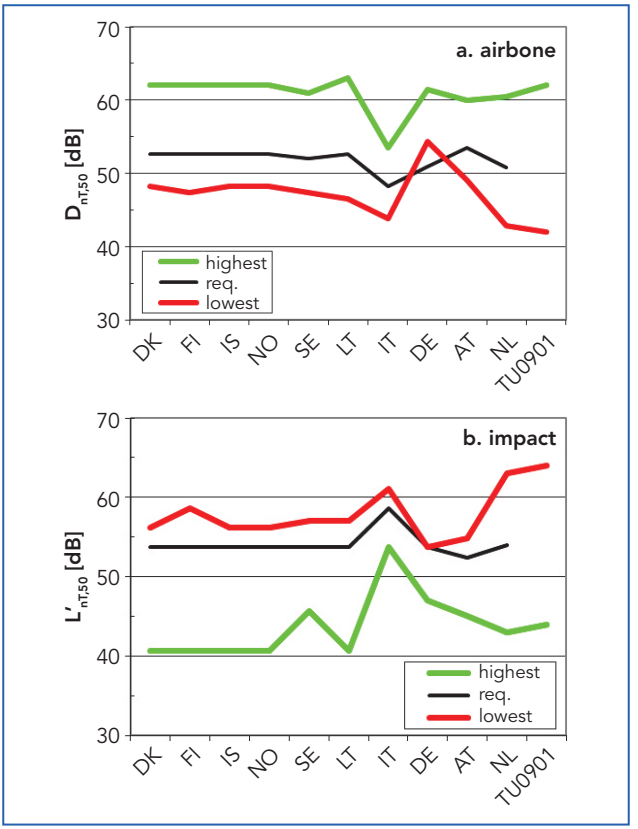

Figure 5.1. *Airborne (a) and impact (b) sound insulation limits for highest and lowest classes in 10 classification schemes in Europe and regulatory requirements for the same countries, all after translation to proposed descriptors (cf. Figures 2.7 and 2.8).*

requirements in countries with existing classification schemes are much closer to the lowest class than the highest class in most cases, thus tending not to consider classification of older, lower performing housing in which the sound insulation is well below the regulatory limit.

5.3. Considerations and decisions during development of proposal

The starting point for the definition of the quality levels is the summary of descriptors presented in Chapter 3. The descriptors cover the frequency

range from 50 Hz to 3150/2500 Hz, but starting at 100 Hz is also considered by using a slightly adjusted class denotation, e.g. X_{100} instead of just X, see 5.4.

Class criteria are included for airborne and impact sound insulation between dwellings, for indoor levels due to outdoor sound or facade sound insulation and for sound levels due to service equipment. Criteria are also recommended for reverberation time in stairwells and common access areas, but only for optional use and not as an element in the classification of a dwelling.

For the steps between classes 4 dB is chosen for all aspects. This is close to the average for the existing schemes for airborne and impact sound insulation, see Chapter 2, corresponds to a substantial step in subjective assessment and also allows easy subdivision for special cases. To cover approximately the whole range of existing classes and most requirements, the proposed classification scheme specifies six classes A-F, thus covering a range of 20 dB, and in addition the denotation npd (no performance determined).

It is felt important to express the meaning of a class in neutral wording as far as possible. The classes for the different aspects are grouped in such a way that globally all aspects (sound insulation and equipment sound) within a specific class are assessed as equally annoying or (dis)satisfying. For such considerations, indications in various classification documents were used, the percentages coming mainly from the present Danish and Dutch classification schemes.

A dwelling can be classified in a specific environment by specifying a limit for the indoor sound levels or for the required facade sound insulation by taking into account the noise exposure L_{den} for that environment. If the environment is not known, the dwelling can be classified in a general suburban environment characterised by an outdoor noise exposure of L_{den} = 55 dB. For balanced comfort, the requirements for a facade should not be too high to allow some acoustical contact with outdoors and to avoid more disturbance by neighbour sounds due to less masking by traffic noise. This means that increasing the sound insulation above a certain value does not result in a higher quality class.

Dwellings can be classified individually or as a whole residential building, if all dwellings fulfil criteria – or even for an individual room. Compliance criteria for class designation are described in 5.4.8. However, further discussions and specifications are needed, for instance on how to

integrate calculations at the design stage according to EN 12354 in the assessment procedure.

For traditional heavy buildings the airborne and impact sound insulation with and without the low frequencies down to 50 Hz differ only marginally. It is thus decided to maintain the same limits for class X and class X_{100} with the clear warning that X_{100} fails to deal adequately with some lightweight and other double constructions.

Based on these considerations – and after having discussed different acoustic characteristics separately - a first complete draft was sent to TU0901 members for comment. Comments were received from 14 countries, often in much detail (28 pages in total). Many of these comments were taken into account for a revised draft presented at the next TU0901 meeting, and further adjustments were made before finalizing the current proposal found in 5.4. Nevertheless, various details need further discussion before a practical working system is reached, and other issues like sound insulation internally in dwellings and classification of environment could be considered as optional or mandatory parts of a classification.

The whole process involved several TU0901 member countries which had no existing classification scheme, and thus an adaptation to the whole idea of a classification has started.

The TU0901 proposal for a classification scheme will be presented to standardization groups in ISO and CEN aiming at further development of the proposal to become a European or even world-wide scheme, thus also reminding people and the building industry about the possibility of integrating the specification of acoustic conditions on equal terms with other qualities for new and renovated housing.

5.3.1. Comparison of proposed classification scheme with current national requirements

It is intended that each country could choose a class as the national regulatory limit. Countries having stricter requirements or class criteria for row housing could then choose one class higher for such housing.

To illustrate the consequences of the proposed system in relation to the current requirements in different countries, a comparison is made for multi-storey housing in Figure 5.2 based on the overview of the current national requirements as collected during this action, translated into the proposed

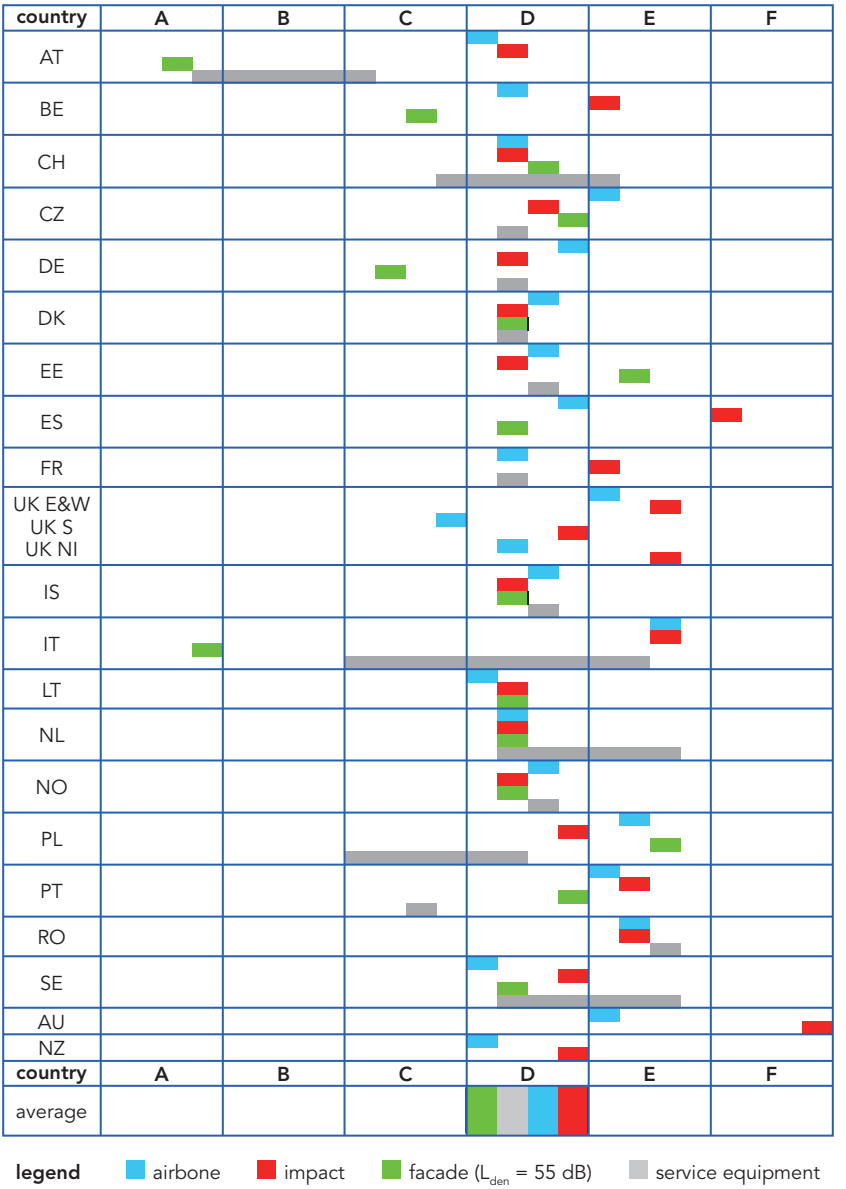

Figure 5.2. *Overview of the classes corresponding to the translated current requirements in the indicated countries. Based on requirements reported from TU0901 members in 19 Countries (UK considered one country), ref. [9].*

descriptors and then compared with the proposed classification system. For facades, the different requirements are transferred into the required facade insulation for an outdoor noise exposure of L_{den} = 55 dB. For sound due to service equipment often a range is indicated, if requirements differentiate between quantities (L_{eq} and L_{max}) or type of equipment.

The countries and numbers considered here in this Chapter 5 do not correspond exactly with what is presented in Chapter 2 with independent studies started several years before TU0901 and later updated and extended to as many countries as possible. Chapter 5 is based on data reporting from TU0901 members, and not all countries responded. However, these differences do not influence the general trends in the data presented here.

It is clear from Figure 5.2 that the current situation for the requirements on average is characterised as class D albeit with large deviations for service equipment and facades. Several countries might expect a higher class in a new scheme, cf. Table 2.8, and thus a discussion on shift of criteria to one class higher might be foreseen.

5.4. TU0901 Proposal: Acoustic classification scheme for dwellings

5.4.1. Introduction - scope

The TU0901 acoustic classification scheme for dwellings has been developed by COST Action TU0901 "Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions". The purpose of the classification scheme is to make it easier for developers to specify and for users to require or be informed about a standardized acoustic quality other than the quality defined by regulations. The classification scheme can also be applied as a general tool to characterise the quality of the existing housing stock and includes provisions for classifying the acoustic quality after renovations have taken place. An additional purpose of the classification scheme is that national authorities can define a specific class in building regulations as the minimum requirement for acoustic conditions in dwellings.

In most countries in Europe, building regulations specify minimum requirements about acoustical conditions for new dwellings. However, complying with regulatory requirements does not guarantee satisfactory conditions for the occupants, and thus there is a need for a classification scheme with classes reflecting different levels of acoustical comfort.

The classification scheme specifies criteria for six classes A, B, C, D, E and F for dwellings, class A being the highest class and F the lowest class. If no acoustic performance is required or the performance is outside the indicated classes or not determined, it can be classified as npd (no performance determined).

The classification includes as class criteria for the above classes minimum values for airborne sound insulation, maximum values for impact sound pressure level and sound pressure levels in the dwellings from service equipment and maximum indoor sound levels or minimum values for insulation from outdoor noise from traffic, industry or other sources in order to assure maximum indoor levels of such sources. Furthermore, maximum values for reverberation time classes for stairwells and common access areas are included as an option for classification, but not a mandatory part of classification of dwellings or buildings.

A classification can be made for a dwelling or for a residential building, if all dwellings in the building fulfil class criteria or even for an individual room. All the requirements given for a class for each acoustic characteristic (sound insulation etc.) shall be fulfilled in order to obtain a classification with a certain class designation. The classification applies as long as there are no adverse changes in building constructions or environment. If such changes occur, the classification shall be reconsidered. Dwellings in building can also be assigned different classes.

The classification of a dwelling or a residential building is based in principle on measurements in accordance with the compliance procedure defined in the scheme. In the design stage an estimate can be made only on the basis of prediction, and predicted performance values could be included in the evaluation in a safe way to enhance the basis for classification.

5.4.2. Normative references

EN ISO 717-1:2013 Acoustics — Rating of sound insulation in buildings and of building elements — Part 1: Airborne sound insulation

EN ISO 717-2:2013 Acoustics - Rating of sound insulation in buildings and of building elements — Part 2: Impact sound insulation

EN ISO 140-4:1998 Acoustics — Measurement of sound insulation in buildings and of building elements — Part 4: Field measurements of airborne sound insulation between rooms. *Note:* To be replaced by ISO/FDIS 16283-1, Acoustics — Field measurement of sound insulation in buildings and of building elements — Part 1: Airborne sound insulation

EN ISO 140-5:1998 Acoustics — Measurement of sound insulation in buildings and of building elements — Part 5: Field measurements of airborne sound insulation of facade elements and facades. *Note:* To be replaced by ISO/NP 16283-3, Acoustics — Field measurement of sound insulation in buildings and of building elements — Part 3: Facade sound insulation

EN ISO 140-7:1998 Acoustics - Measurement of sound insulation in buildings and of building elements — Part 7: Field measurements of impact sound insulation of floors *Note:* To be replaced by ISO/CD 16283-2, Acoustics — Field measurement of sound insulation in buildings and of building elements — Part 2: Impact sound insulation

EN ISO 3382-2:2008 + Cor 1:2009 Acoustics — Measurement of room acoustic parameters — Part 2: Reverberation time in ordinary rooms

EN 12354-1:2000 (ISO 15712-1:2005) Building acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 1: Airborne sound insulation between rooms

EN 12354-2:2000 (ISO 15712-2:2005) Building acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 2: Impact sound insulation between rooms

EN 12354-3:2000 (ISO 15712-2:2005) Building acoustics — Estimation of acoustic performance of buildings from the performance of elements — Part 3: Airborne sound insulation against outdoor sound

EN ISO 10052:2004 Acoustics — Field measurements of airborne and impact sound insulation and of equipment noise — Survey methods. + Amd 1:2010

EN ISO 16032:2004 Acoustics — Measurement of noise from service equipment in buildings — Engineering method

5.4.3. Definitions

For the purpose of this TU0901 proposal for a classification scheme the following definitions apply:

Classes A, B, C, D, E, F and npd

Six classes A-F specifying different levels of acoustic conditions in dwellings. Class A is the highest class, class F the lowest class. The meaning of classes is explained in 5.4.10. The indication npd can be used

for dwellings were no acoustic performance is required or determined or if the performance does not even comply with class F. For sound insulation (airborne and impact), the default frequency range is 50 Hz to 3150 Hz. However, an alternative frequency range 100-3150 Hz is possible resulting in a class denotation X_{100}, e.g. B_{100}.

Airborne sound insulation between rooms

This is the characteristic of a building construction to insulate against airborne sound transmission in a building. The measurement result is given as a single-number quantity expressed in decibels (dB).

The specified class limits are related to measurements in situ in frequency bands according to EN ISO 140-4, and evaluation according to EN ISO 717-1 and expressed in the descriptor: $D_{nT,50} = D_{nT,w} + C_{50\text{-}3150}$ as defined in EN ISO 717-1.

As an alternative to $D_{nT,50}$, the performance can be estimated for all types of construction by the currently more common descriptor $D_{nT,100} = D_{nT,w} + C$ as also determined according to EN ISO 717-1. However, in case of light-weight building constructions and composed elements with low frequency resonances, the evaluation will most likely not be safe. If $D_{nT,100}$ is applied, the class denotation is X_{100}, e.g. B_{100}.

Impact sound pressure level

This characterises the extent to which a building construction transfers impact sound within the building. The measurement result is given as a single-number quantity s expressed in decibels (dB).

The specified class limits are related to measurements in situ in frequency bands according to EN ISO 140-7, and evaluation according to EN ISO 717-2 and expressed in the descriptor: $L'_{nT,50} = L'_{nT,w} + C_{I,50\text{-}2500}$ as defined in EN ISO 717-2.

Experience has shown that when applying this low-frequency rating, potentially disturbing high frequency sounds are not rated appropriately. For this reason, an additional criterion for $L'_{nT,w}$ is applied with the same limit value, while awaiting a future improved weighting procedure that solves this problem adequately.

As an alternative to $L'_{nT,50}$, the performance can be estimated for all types of constructions by the currently more common descriptor $L'_{nT,100} = L'_{nT,w} + C_I$ as also determined according to EN ISO 717-1. However, in case of

light-weight building constructions and composed elements with low frequency resonances the evaluation will most likely not be safe. If $L'_{nT,100}$ is applied, the class denotation is X_{100} , eg. B_{100}.

Airborne sound insulation of facades

This characterises the facade's ability to insulate against airborne sound transmission into a building. The measurement result is given as a single-number quantity expressed in decibels (dB).

The specified limits are related to measurements in situ in frequency bands according to EN ISO 140-5, and evaluation according to EN ISO 717-1, and expressed in the descriptor: $D_{2m,nT,50} = D_{2m,nT} + C_{tr,50\text{-}3150}$ or + $C_{50\text{-}3150}$, depending on type of outdoor noise and as defined in EN ISO 717-1

As an alternative to $D_{2m,nT,50}$, the performance can be estimated for all types of construction by the currently more common descriptor $D_{2m,T,100} = D_{2m,nT,w} + C_{tr}$ or C as also determined according to EN ISO 717-1. However, in case of light-weight building constructions and composed elements with low frequency resonances, the evaluation will most likely not be safe. If $D_{2m,nT,100}$ is applied, the class denotation is X_{100} , eg. B_{100}.

Service equipment sound pressure level

This characterises the received sound pressure level in rooms due to the operation of a specific piece of service equipment or plant in a building. The measurement result is given as a single-number quantity expressed in decibels (dB). The specified limits are related to measurements in situ, either in frequency bands in accordance with EN ISO 16032 or directly in A-weighted levels in accordance with EN ISO 10052. The measurements concern either the A-weighted equivalent sound level or the A-weighted maximum F sound level during a specified working cycle of considered equipment. These working conditions are specified for various types of equipment in the mentioned standards. The descriptors are L_{eq} and L_{maxF} , resp. $L_{eq,nT,A}$ and $L_{maxF,nT,A}$ as defined in EN ISO 16032 and EN ISO 10052.

Reverberation time

The time that would be required for the sound pressure level to decrease by 60 dB after the sound source has stopped. The quantity is denoted by T, and is expressed in seconds (s).

The specified limits are related to space averaged reverberation times in each of the octave bands 250, 500 1000 and 2000 Hz.

Measurements are carried out according to EN ISO 3382-2.

5.4.4. Airborne & Impact sound insulation

The minimum values of the classes for airborne sound insulation are shown in Table 5.1.

Table 5.1. Airborne sound insulation between dwellings and other rooms. Class limits.[(1),(2)]

Type of space	Class A $D_{nT,50}$ (dB)	Class B $D_{nT,50}$ (dB)	Class C $D_{nT,50}$ (dB)	Class D $D_{nT,50}$ (dB)	Class E $D_{nT,50}$ (dB)	Class F $D_{nT,50}$ (dB)
Between a dwelling and premises with noisy activities [(3)]	≥ 68	≥ 64	≥ 60	≥ 56	≥ 52	≥ 48
Between a dwelling and other dwellings and rooms outside the dwelling	≥ 62	≥ 58	≥ 54	≥ 50	≥ 46	≥ 42

NOTES

(1) $D_{nT,50} = D_{nT,w} + C_{50\text{-}3150}$;

(2) As an alternative to $D_{nT,50}$, the performance can be estimated for all types of construction by the currently more common descriptor $D_{nT,100} = D_{nT,w} + C$, see clause 3. If $D_{nT,100}$ is applied, the class denotation is X_{100} , eg. B_{100}.

(3) Premises with noisy activities are rooms for shared services like laundries, central boiler house, joint/commercial kitchens or commercial premises like shops, workshops or cafés. However, in each case, noise levels must be estimated and the sound insulation designed accordingly, e.g. for party rooms, discotheques etc. Offices are normally not considered as noisy premises, and the same criteria as for dwellings apply.

The maximum values of the classes for impact sound pressure level are shown in Table 5.2.

5.4.5. Facade sound insulation

The facade sound insulation shall assure an indoor sound level for which the maximum class limits are shown in Table 5.3a. This can be achieved in two ways: by specifying these maximum indoor levels or by specifying a minimum facade sound insulation on the bases of the outdoor sound impact ($D_{2m,nT,50} = L_{den} + 3 - L_{den,indoor}$). In the latter case the minimum values for the classes of the facade sound insulation are shown in Table 3b, either for a general suburban environment or for a specific environment as characterised by L_{den} for the relevant outdoor sound sources.

Table 5.2. Impact sound pressure level in dwellings. Class limits.[(1),(2),(3)]

Type of space	Class A $L'_{nT,50}$ (dB)	Class B $L'_{nT,50}$ (dB)	Class C $L'_{nT,50}$ (dB)	Class D $L'_{nT,50}$ (dB)	Class E $L'_{nT,50}$ (dB)	Class F $L'_{nT,50}$ (dB)
In dwellings from premises with noisy activities[(4)]	≤ 38	≤ 42	≤ 46	≤ 50	≤ 54	≤ 58
In dwellings from other dwellings	≤ 44	≤ 48	≤ 52	≤ 56	≤ 60	≤ 64
In dwellings: – from common stairwells and access areas – balconies, terraces, bath, toilet not belonging to own dwelling	≤ 48	≤ 52	≤ 56	≤ 60	≤ 64	≤ 70

NOTES

(1) $L'_{nT,50} = L'_{nT,w} + C_{I,50\text{-}2500}$

(2) The same limit values are to be fulfilled by $L'_{nT,w}$.

(3) As an alternative to $L'_{nT,50}$, the performance can be estimated for all types of constructions by the currently more common descriptor $L'_{nT,100} = L'_{nT,w} + C_I$, see Clause 3. If $L'_{nT,100}$ is applied, the class denotation is X_{100}, eg. B_{100}.

(4) Premises with noisy activities are rooms for shared services like laundries, central boiler house, joint/commercial kitchens or commercial premises like shops, workshops or cafés. However, in each case, noise levels must be estimated and the sound insulation designed accordingly, e.g. for party rooms, discotheques etc. Offices are normally not considered as noisy premises, and the same criteria as for dwellings apply.

If fulfilling these limits requires a very high facade sound insulation, say more than $D_{2m,nT,50} \geq 35$ dB, it is questionable whether the overall quality is really increased (less contact with living environment, sounds from the neighbour more audible) and therefore assigning a high class could be restricted.

Table 5.3a. Sound levels in dwellings due to outdoor sounds. Class limits.[(1)]

Type of space	Class A $L_{den,indoor}$ (dB)	Class B $L_{den,indoor}$ (dB)	Class C $L_{den,indoor}$ (dB)	Class D $L_{den,indoor}$ (dB)	Class E $L_{den,indoor}$ (dB)	Class F $L_{den,indoor}$ (dB)
In dwellings from outdoor sound sources; for each type of source	**≤ 23**	**≤ 27**	**≤ 31**	**≤ 35**	**≤ 39**	**≤ 43**

NOTES

(1) $L_{den,indoor}$ is the normalized A-weighted indoor sound level with weighting of the day, evening, night period over the frequency range from 50 Hz to 5000 Hz as defined in the END for outdoor sound.

Table 5.3b. *Facade sound insulation in dwellings. Class limits.*[(1), (2)]

Type of space	Class A $D_{2m,nT,50}$ (dB)	Class B $D_{2m,nT,50}$ (dB)	Class C $D_{2m,nT,50}$ (dB)	Class D $D_{2m,nT,50}$ (dB)	Class E $D_{2m,nT,50}$ (dB)	Class F $D_{2m,nT,50}$ (dB)
In dwellings from outdoors; general suburban environment L_{den} = 55 dB.[(3)]	≥ **35**	≥ **31**	≥ **27**	≥ **23**	≥ **19**	≥ **15**
In dwellings from outdoors; specific environment with sound sources characterised by L_{den}.[(4),(5)]	≥ L_{den}-20	≥ L_{den}-24	≥ L_{den}-28	≥ L_{den}-32	≥ L_{den}-36	≥ L_{den}-40

NOTES

(1) $D_{2m,nT,50} = D_{2m,nT,w} + C_{tr,50\text{-}3150}$ in general. However, if the type of outdoor source is better characterised by the C spectrum, for instance for some types of railway traffic, $D_{2m,nT,50} = D_{2m,nT,w} + C_{50\text{-}3150}$ can be used. In some countries this performance applies to a ventilated facade according to ventilation requirements

(2) As an alternative to $D_{2m,nT,50}$ the performance can be estimated for all types of constructions by the currently more common descriptor $D_{2m,nT,100} = D_{2m,nT,w} + C_{tr}$ (or $=D_{2m,nT,w} + C$), see Clause 3. If $D_{2m,nT,100}$ is applied, the class denotation is X_{100}, e.g. B_{100}.

(3) L_{den} is the free field level for the general outdoor traffic sound as defined for the END; the typical background sound levels in this environment will be 45-50 dB in daytime.

(4) L_{den} is the free field level for the relevant outdoor sound sources as defined for the END.

(5) For a classification including the environment the requirement must be increased in the same amount as the noise impact is higher than L_{den} = 55 dB as is indicated in the third row.

5.4.6. Noise from building service equipment

The maximum values of the classes for sound levels due to service equipment are shown in Table 5.4.

5.4.7. Reverberation time in stairwells and joint access areas

Classification of reverberation time is an option, but not a mandatory part of classification of dwellings or buildings. The results can be given as additional information or omitted (in which case npd is indicated).

The maximum values of the classes for reverberation time are shown in Table 5.5.

Table 5.4. Sound levels in dwellings due to building service equipment. Class limits.(1)

Type of space and sources (2)	Class A L_{eq} or L_{maxF} (dB)	Class B L_{eq} or L_{maxF} (dB)	Class C L_{eq} or L_{maxF} (dB)	Class D L_{eq} or L_{maxF} (dB)	Class E L_{eq} or L_{maxF} (dB)	Class F L_{eq} or L_{maxF} (dB)
In dwellings due to ventilation / heating / cooling installation L_{eq}.	≤ 20	≤ 24	≤ 28	≤ 32	≤ 36	≤ 40
In dwellings due to use of toilet, bath, shower in neighbour dwellings L_{maxF}.	≤ 20	≤ 24	≤ 28	≤ 32	≤ 36	≤ 40
In dwellings due to other sources (lift, water supply, pumps, garage doors, etc.) L_{maxF}.	≤ 25	≤ 29	≤ 33	≤ 37	≤ 41	≤ 45

NOTES

(1) L_{eq} and L_{maxF} are resp. $L_{A,eq,nT}$ and $L_{AF,max,nT}$ as defined in ISO 16032 and ISO 10052

(2) Requirements relate to sounds that occur more than occasionally due to service equipment in neighbouring dwellings, general equipment serving the whole building and service equipment in the own dwelling for ventilation / heating / cooling.

Table 5.5. Reverberation time, maximum values for T. Class limits.

Type of space	Class A T (s)	Class B T (s)	Class C T (s)	Class D T (s)	Class E T (s)	Class F T (s)
Common stairwells and joint access areas	≤ 0,8	≤ 1,0	≤ 1,3	≤ 1,6	≤ 2,0	≤ 2,5

NOTES

(1) The limits are averaged reverberation times and apply in each of the octave bands 250, 500, 1000 and 2000 Hz, see Clause 3.

(2) Since often measuring and predicting the reverberation time is rather difficult and inaccurate in such enclosed areas, the requirement on the reverberation time could be replaced by one on the calculated amount of applied equivalent absorption area $A \geq 0{,}16\ V / T_{limit}$.

5.4.8. Guidelines for verification of compliance with an acoustic class

5.4.8.1. General

The aim of this guideline is to facilitate national implementation of this classification scheme and practical application of the acoustic classification of a residential building, individual dwellings or even a room or a specific acoustic characteristic for a room, in the following denoted a unit.

The following conditions should be considered when a unit is subject to an evaluation of compliance with the criteria of a specific acoustic class.

The classification of a unit applies from a certain date. The classification is valid as long as the building constructions remain unaltered. If changes occur, the classification has to be reconsidered. This may for instance be relevant in case of changes in constructions or in outdoor noise conditions. In the design stage of a building or in case of changes in a building, an estimation of the class can only be determined by calculations; it is advisable to keep then a safety margin of at least half a class (2 dB).

5.4.8.2. Verification of compliance with criteria for an acoustic class

The compliance of a unit with a class is documented by measurements in the completed unit. Acoustic measurements are performed according to the relevant standards specified in the main body of this classification scheme in order to verify the compliance with the class criteria. The persons or organizations that are appointed to make the relevant measurements shall be qualified for the task. The contents of a report of acoustic classification are given in Clause 5.4.8.3.

General principles

When verifying the acoustic class of a unit, the general principle is that a sufficient number of measurements of each relevant acoustic characteristic must be performed in order for the result to represent the unit. Care should be taken to include the critical sites/rooms, e.g. partitions with critical flanking constructions. To enhance the basis for classification, performance predictions by calculation may be a supplement to the measurements, applying a sufficient safety margin. An expert in acoustics selects the structures and spaces to be measured in such a way that they are sufficiently representative of the unit. It must be noted that in order to achieve the class set as a goal, all measurement results must in principle

meet the criteria of the class in question. However, compliance is granted, if the average results comply with class limits, and no individual result deviates adversely by more than 2 dB.

If classification for different dwellings, rooms or acoustic characteristics varies, the classification assigned is the minimum class obtained, when considering all relevant acoustic characteristics. However, additional assignments of higher classes for individual dwellings, rooms or acoustic characteristics can be made according to the rules for such units, see below.

If for sound insulation, the alternative frequency range down to 100 Hz is applied, the class denotation is X_{100} , eg. B_{100}, and the same rules for assigning a class are applied. One then must realize X_{100} fails to deal adequately with some lightweight and other double constructions.

If no acoustic performance is required or the performance is outside the indicated classes or not determined, it can be declared as npd (no performance determined).

Verification of an entire building

When an entire building is to be tested, the number of samples for measurement of airborne and impact-sound insulation and noise levels is 5% of the spaces or structures. However, the minimum number of measurements for each structure type and acoustic characteristic is always 3.

Verification of individual dwellings, rooms or acoustic characteristic

Individual dwellings, rooms or acoustic characteristic in a building may be classified, if each of them complies with the relevant class limits. The above-mentioned general principles apply.

Minimum number of measurements for each type of structure, room or acoustic characteristic is normally two.

5.4.8.3. Contents of verification report for classification of a dwelling or building

Reports, in which the acoustic classification of a dwelling or a building is presented according to this classification scheme, must be uniform and concise. The first page of the report should contain only the most essential information, such as the objective of the measurements, the client, name

of the person(s) or organization responsible for the verification, the number of dwellings verified, the measurements dates, the main results, the class obtained, other relevant information, a reference to this classification scheme and signatures.

Detailed information about measurement methods, the dwelling(s) or building and the measurement results should be presented in appendices of the classification report. Reference should be made to the specific test reports (with frequency dependent results) being the basis of the class assignment.

In case of different classes for different dwellings, rooms or acoustic characteristics, the report could include overview tables with classes obtained for the different acoustic characteristics and/or for different dwellings or rooms.

5.4.9. Classification examples

Four examples are shown below for the presentation of classification results determined according to the procedure in 8.2. In all cases the verification report must include information as described in 8.3. The four examples are:

1. Classification of a residential building with one class for the entire building.
2. Classification of a dwelling with one class for the entire dwelling.
3. Classification of a residential building with individual class indication for each acoustic characteristic.
4. Classification of a dwelling with individual class indication for each acoustic characteristic.

Example 1: A residential building has obtained Class D, as a minimum this class has been fulfilled for all individual acoustic characteristics.

Example 2: A dwelling No. NNN has obtained Class C, as a minimum this class has been fulfilled for all individual acoustic characteristics for the dwelling.

Example 3: Classification of a residential building with individual class indication for each acoustic characteristic.

Acoustic classification of residential building with several dwellings and no noisy premises							
Acoustic characteristic	Class						
	A	B	C	D	E	F	npd
Airborne sound insulation				X			
Impact sound pressure level				X			
Facade sound insulation			X				
Noise from building service equipment			X				
Rev.time in stairwells etc. (optional)							X

The classification result for the entire building is Class D, which is the lowest class for individual acoustic characteristics.

Example 4: Classification of a dwelling with individual class indication for each acoustic characteristic.

Acoustic classification of dwelling No. NNN in residential building with no noisy premises							
Acoustic characteristic	Class						
	A	B	C	D	E	F	npd
Airborne sound insulation			X				
Impact sound pressure level			X				
Facade sound insulation		X					
Noise from building service equipment			X				
Rev.time in stairwells etc. (optional)							X

The classification result for the entire dwelling is Class C, which is the lowest class for individual acoustic characteristics.

5.4.10. Explanation of meaning of classes

Table 5.6. *Description in general terms of the quality of the different classes*

Class	General	Sound insulation judged poor
A	A quiet atmosphere with a high level of protection against sound	less than 5%
B	Under normal circumstances a good protection without too much restriction to the behaviour of the occupants	around 5%
C	Protection against unbearable disturbance under normal behaviour of the occupants, bearing in mind their neighbours	around 10%
D	Regularly disturbance by noise, even in case of comparable behaviour of occupants, adjusted to neighbours	around 20%
E	Hardly any protection is offered against intruding sounds	around 35%
F	No protection is offered against intruding sounds	50% or more

NOTE: the indicated percentages are just a global indication; the trend is rather well based in literature, but the absolute numbers depend very much on the setting and wording of questionnaires used.

Table 5.7. *Global indication of what can be expected for some airborne and impact sound sources.*

Sources:	A	B	C	D	E	F
very loud speech	just audible, but not intelligible	audible, but hardly intelligible	just intelligible	intelligible	clearly intelligible	
loud speech	hardly audible	just audible, but not intelligible	audible, but hardly intelligible	just intelligible	intelligible	clearly intelligible
normal speech	not audible	hardly audible	just audible but not intelligible	hardly intelligible	just intelligible	intelligible
very loud music, party	just audible	audible	clearly audible	very clearly audible		
loud music	not audible	just audible	audible	clearly audible	very clearly audible	
normal music	not audible		just audible	audible	clearly audible	very clearly audible
walking	not audible	hardly audible	just audible	audible	clearly audible	very clearly audible
kids playing	hardly audible	Just audible	audible	clearly audible	very clearly audible	
dropping & moving objects	not audible	hardly audible	just audible	audible	clearly audible	very clearly audible

NOTE: if sounds are audible depends not only on the building construction but also on the background noise of the environment. These descriptions reflect the average situation in a reasonably quiet suburban environment, as is the basis for the general classification of the facade sound insulation. In a quieter environment the description will shift to the left, while in a noisier environment the description will shift to the right.

5.4.11. References

The below references are related to publications with overview descriptors, regulations and classification schemes in Europe or to principles of classification schemes. Exact references for national classification schemes are found in the below overview publications.

[1] *"Acoustic quality and sound insulation between dwellings"* by J.H. Rindel, Journal of Building Acoustics, 1999, Vol. 5, pp. 291-301.

[2] *"Sound Classification of Dwellings – Quality Class Ranges and Class Intervals in National Schemes in Europe"* by B. Rasmussen. EuroNoise 2012, Prague, Czech Republic, 2012. http://vbn.aau.dk/en/persons/birgit-rasmussen(c0e774a9-8cdf-410f-8727-6a2cc11a4f14)/publications.html

[3] *"Sound insulation between dwellings – Overview of the variety of descriptors and requirements in Europe"*, by B. Rasmussen, Forum Acusticum 2011, Aalborg, Denmark, Paper ID 573.Acustica United with Acta Acustica, 2011, Vol. 97 Supplement 1. http://vbn.aau.dk/en/persons/birgit-rasmussen(c0e774a9-8cdf-410f-8727-6a2cc11a4f14)/publications.html

[4] *"Harmonization of sound insulation descriptors and classification schemes in Europe: COST Action TU0901"* by Birgit Rasmussen. EAA TC-RBA & COST TU0901 Symposium, December 2010, Florence, Italy. http://vbn.aau.dk/en/persons/birgit-rasmussen(c0e774a9-8cdf-410f-8727-6a2cc11a4f14)/publications.html

[5] *"Sound classification of dwellings in the Nordic countries – Differences and similarities between the five national schemes"* by B. Rasmussen. BNAM 2012, Odense, Denmark, June 2012. http://vbn.aau.dk/en/persons/birgit-rasmussen(c0e774a9-8cdf-410f-8727-6a2cc11a4f14)/publications.html

[6] *"Sound insulation between dwellings – Descriptors in building regulations in Europe"* by Birgit Rasmussen & Jens Holger Rindel. Applied Acoustics, 2010, 71(3), 171-180. http://dx.doi.org/10.1016/j.apacoust.2009.05.002;

[7] *"Sound insulation between dwellings – Requirements in building regulations in Europe"* by Birgit Rasmussen. Applied Acoustics, 2010, 71(4), 373-385. http://dx.doi.org/10.1016/j.apacoust.2009.08.011;

[8] "Model-based assessment scheme for acoustic quality in buildings", by Eddy Gerretsen. NAG-DAGA 2009, Rotterdam.

[9] "European variety of descriptors for building acoustic performance and translation into proposed harmonized descriptors" by Eddy Gerretsen. InterNoise2013, Sept. 2013, Innsbruck, Austria.

Notes:

A list of published national classification schemes updated to March 2012 is found in ref. [2]. References [2]-[7] are based on analysis of published regulations and classification schemes, and studies are made independently from TU0901. Information in [9] may differ from [2]-[7], especially about classification schemes, because [9] is based on a survey in 2010-2011 with self-reported data from TU0901 members and also includes drafts and does not include all published classification schemes.